Assessment of body motions using Motion Energy Analysis – Instructions for MATLAB© scripts

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1 Background

Motion Energy Analysis (MEA) is a computerized method to automatically assess body motions of videotaped individuals. This computer vision method has been applied to assess body movements in many research areas. For example, correlations between body motions and severity of negative symptoms in patients with schizophrenia (Kupper, Ramseyer, Hoffmann, Kalbermatten, & Tschacher, 2010; Kupper, Ramseyer, Hoffmann, & Tschacher, 2015) or between politicians' movement patterns and their personalities (Koppensteiner & Grammer, 2010) have been reported. Furthermore, synchronisation of body motions assessed with MEA has been examined in positive versus negative situations in children interactions (Altmann, 2010, 2011, 2013) and adult interactions (Paxton & Dale, 2012; Tschacher, Rees, & Ramseyer, 2014). MEA has also been applied to analyse the nonverbal behaviour in a psychotherapeutic context via studying the synchronisation of motions in patient-psychotherapist interactions (Galbusera, Finn, & Fuchs, 2016; Ramseyer, 2011; Ramseyer & Tschacher, 2011, 2014). Furthermore, the synchronisation of voice and body motion in mother-new born baby interactions (Watanabe, 1983), teacher-learning group interactions (Katsumata, Ogawa, & Komori, 2009), and in courtship communication (Grammer, Honda, Juette, & Schmitt, 1999) have been examined using motion energy time series (METS). Moreover, MEA is commonly used in human-machine interactions, whereby robots use MEA to perceive human motions, gestures etc. (Bobick, 1997; Boehme et al., 1998).

Starting from the point that motion behaviour of two persons is recorded using a digital video, the attached MATLAB© scripts assess their body motions. A detailed explanation is given by Altmann (2013) (in German) and Altmann et al. (2018) (in English). The attached MATLAB© scripts regarding MEA were written and developed by Uwe Altmann. In an ongoing project of the Institute of Psychosocial Medicine and Psychotherapy (Jena, Germany), the scripts were extended by Désirée Thielemann so that pre-processing steps (e.g. smoothing) and sub-routines of time series analysis run with one script. Furthermore scripts for easier data handling were added (e.g. graphical user interface for the selection of regions of interest). You can apply the attached scripts on your own data.

2 Instructions for Motion Energy Analysis

2.1 Convert Video file to a format that is supported by MATLAB© routine VideoReader (e.g., `.AVI`)

2.2 Mark Region-of-interest (ROI) with function `MEA_ROI_freehand_v03.m`

- Input parameters are
  - `workingDir` = Please specify working directory (if not, a pop-up menu appears where you have to choose the directory)

- `frame_no` = Please specify frame number which is displayed for drawing ROI (default is frame 3000 = minute 2)

- Run script and draw ROI
  - ROIs in this script are defined as
    - 1st: patient body
    - 2nd: therapist body
    - 3rd: patient head
    - 4th: therapist head
  - Additionally there are 4 Background ROIs specify to filter video errors (highlighted at the picture where ROIs have to be drawn)
    - Only two are used → lower background ROI are used if the persons are situated in the upper area of the video, upper background ROI are used if the persons are situated in the lower area of the video (default is upper background ROIs, lower ones are only used if the ROIs drawn are overlapping with the upper background ROI)
- After drawing ROIs a file is saved where the 4 person-centered ROIs and two background ROIs are stored

2.3 Run motion energy analysis with function `motion_energy_analysis.m`

- Input parameters are
  - `videoNames` = Please specify the name of the video that has to be analyzed (Note, that also the ROI-file of this video has to be stored in the same folder)
  - `cut_off` = Please specify cut-off for meaningful pixel change intensity (default is 15)
    - you can also determine the cut-off for your videos empirically by using the functions `MEA_cut.m and check_for_cut_off.m (see below)`
  - `numberFrames` = Please specify number of frames that have to be analyzed (default is 22501 frame = 15 min with 25fps + 1 frame)
- Output of the function is a `.txt` file containing the motion energy values for the video sequence in 6 columns
  - 1st: patient body
  - 2nd: therapist body
  - 3rd: background ROI 1
  - 4th: background ROI 2
  - 5th: patient head
  - 6th: therapist head

2.4 Determine cut-off for meaningful pixel intensity changes empirically Function `MEA_cut_off.m`

- Input parameters are
  - `workingDir` = Please specify working directory (if not, a pop-up menu appears where you have to choose the directory)
  - `numberFrames` = Please specify number of frames that have to be analyzed (default is 15000 frame = 10 min with 25fps)
- Please check video suitability before applying MEA_cut_off.m:
  - first draw ROI as described in 2.2
  - run function `check_video_for_cutoff.m`
    - Input parameter:
      - `videoNames`: Please specifiy video name
  - function displays if video is suitable for cut-off estimation
  - suitability is dependent on the location of the person-centered ROI – they should not overlap with the pixels used for cut-off estimation
- Output of the function `MEA_cut_off.m` is a file containing the 95% quantile and the 99% quantile of pixel intensity changes

- We recommend to use the 99% quantile as cut-off for MEA

2.5 Preprocessing of ME time series

- Standardization: due to the fact that the size of the ROI can be stored, a standardization with the ROI-size is possible
    - By using the function `standardize_ROIsize.m` the ME time series is divided by its ROI size and multiplied by 100
    - Output: `.txt` file containing 6 columns (like the not standardized time series), values can range between 0 and 100 → 0 means that 0% of the ROI is activated, 100 means that 100% of the ROI are activated
- Correcting video errors: `function filter_video_errors_in_TS.m`
    - Errors are characterized by "strong and short jumps"
    - **IMPORTANT**: We recommend a linear tranformation using the function `standardize_ROIsize.m` before running this function (the result is that 0 = no motion and 100 = 100% of ROI was activated). Using this function before, here a cutoff=25 means 25% of ROI
    - Input parameters:
        - `TS_old` = Please specify old time series (standardized)
        - handle_as_split_screen_video = boolean (true / false) which indicate that the corresponding video of the given time series is a split screen,
            - if no split screen, values of patient AND therapist are set to missing value if an error occurred
            - if it is a split screen video, then only for one person the value is set to missing if an error occurred
        - `cut_off_background` = if the amount of background ROI is lager then this cut-off, then we expect a video error and set the time series values to missing value (normally, in the background ROI is no activity resp. all values are zero for such ROI) → default is 5
        - `cut_off_body` = we computed the change from t to t+1. if the amount of change at one time point is larger than this cutoff value, then the time series of BODY movements is set to missing at this time point. →default is 15
        - `cut_off_head` = we computed the change from t to t+1. if the amount of change at one time point is larger than this cut-off value, then the time series of HEAD movements is set to missing at this time point. → default is 25
    - Output parameters
        - `TS_new` = output with the same size such as `TS_old`; if no video errors occur, then the values of `TS_new` and `TS_old` are equal
        - `video_errors` = matrix with same size such as `TS_old`; optional output; it indicates with zero and ones at which time point a video error occurred

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